

THE HIGH FLUX TEST MODULE OF IFMIF-DONES

Frederik Arbeiter, Florian Schwab, Sergej Gordeev, Yuefeng Qiu

Background and Objective

The High Flux Test Module (HFTM) of IFMIF-DONES (International Fusion Materials Irradiation Facility – DEMO-oriented Neutron Source) is developed as device to irradiate a large number of small scale specimens of steels in the high neutron flux region (5×10^{14} n/cm²/s) of DONES.

Irradiation performance

- 4x3 capsules with 15x39x80 mm³ "payload", ~105 specimens/capsule
- Irradiation temperatures 250 – 550 °C, homogeneity +/-3%
- ~ 850 specimens can be irradiated to 12 – 25 dpa/fpy
- 13-15 appm(He)/dpa, 50-60 appm(H)/dpa
- Instrumentation: 6x type K thermocouples, activation foils, SPND, MFC.

Major design changes in the WPENS/DONES phase

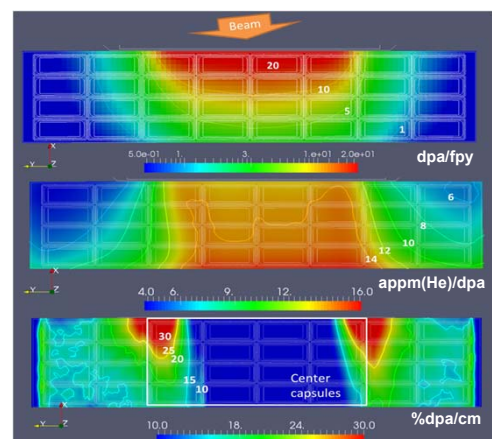
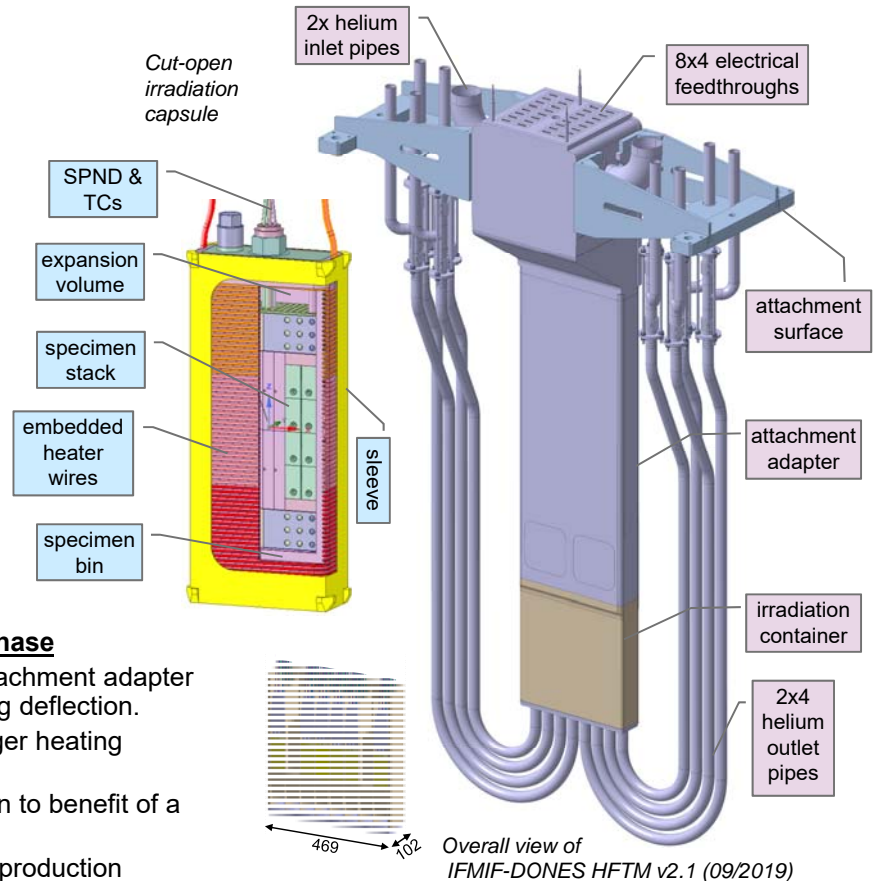
- Reversal of flow direction: to keep the upper attachment adapter at low and homogenous temperature, minimizing deflection.
- Enlargement of capsule thickness to enable larger heating winding radii for longer heater lifetime
- Extension of irradiation volume in beam direction to benefit of a low gradient zone of nuclear responses
- Change from Ni to Cu-based brazing : Less He production (swelling) and less activation
- Substituted NaK with Na as heat conduction filler to avoid argon production (several cm³ → pressurization, bubbles)
- New capsule sealing concept to allow depressurization
- Container with integrated minichannels : higher stiffness, improved capsule installation.

Characteristic data

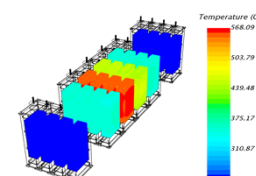
- Bounding box : 635 (102) mm x 1700 (469) mm x 2988 mm
- Masses: Total 680 kg, 40 kg irradiation capsules with specimens
- Heating: Nuclear 2.3 W/g peak, 17 kW tot., 1.5 kW electr. per capsule
- Activation at shutdown: 8×10^{15} Bq, decay heat 900 W
- Helium flow 140 g/s, 0.35 MPa , 50 °C at inlet.

Qualitative lifetime considerations

- Objective: 1 year corrs. 50 dpa, extension to 2.5 years
- Pressure bearing shell X2 CrNiMo 17 12 2 at < 160 °C
 - qualified for up to 53 dpa acc. RCC-MRx
 - negligible creep, negligible swelling
- Eurofer-97 specimen capsules at 250 °C < T < 550 °C
 - qualified only up to 13.3 dpa acc. RCC-MRx → no SIC
 - significant creep regime, but pressurization stresses minimized by evacuation before sealing
- Heater lifetime is investigated by reactor irradiation, voltages limited (< 150 V) to reduce RIC/RIED effects in the MgO electrical insulator.



Nuclear responses (beam level)



T _{nom}	+ΔT/T _{nom}	-ΔT/T _{nom}
250 °C	+0.5%	-0.8%
350 °C	+3.0%	-1.8%
450 °C	+2.0%	-2.0%
550 °C	+2.2%	-0.6%

Temperature spread in specimen stack